594-C-87 FEMA, 209, 410058

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FLOOD INSURANCE STUDY

ORIGINAL

COMPLETED
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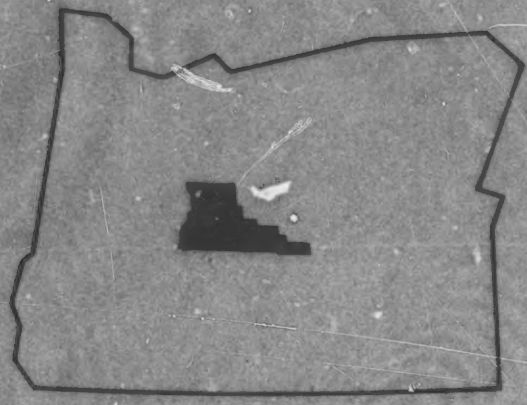
CITY OF SISTERS, OREGON
DESCHUTES COUNTY



SEPTEMBER 29, 1986

Federal Emergency Management Agency

COMMUNITY NUMBER - 410058

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Squaw Creek Panel 01P

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PUBLISHED SEPARATELY:

Flood Insurance Rate Map

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Sisters, Deschutes County, Oregon, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound flood plain management. Minimum flood plain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR 60.3.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by the U.S. Army Corps of Engineers (COE), Portland District, for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. EMW-E-1153, Project Order No. 1, Amendment No. 29. This study was completed in March 1985.

1.3 Coordination

The initial coordination and precontract meeting for the City of Sisters was held on July 11, 1983. The meeting was attended by representatives of FEMA, the COE, and the city. The purpose of the meeting was to inform the city of its status in the NFIP, to gather all available pertinent data on flooding in the community, and to reach an agreement on areas to be studied.

Coordination continued throughout the study. In November and December 1983, letters were sent to the U.S. Bureau of Reclamation, U.S. Geological Survey (USGS), U.S. Soil Conservation Service, Oregon Water Resources Department, Oregon Department of Transportation,

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and State Director of the Bureau of Land Management to gather available flood information and pertinent flood data.

The final community coordination meeting was held on September 23, 1985, and attended by representatives of FEMA, the study contractor, and the community. All problems raised at that meeting have been addressed in this study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Sisters, Deschutes County, Oregon. The area of study is shown on the Vicinity Map (Figure 1).

A 0.8-mile reach of Squaw Creek within the corporate limits was studied by detailed methods.

The area studied by detailed methods was selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through 1990.

2.2 Community Description

The City of Sisters is located in west-central Deschutes County, on the east slope of the Cascade Mountains in central Oregon.

Settlement in the Sisters area began about 1865, when Captain LaFollette and a band of Company A - 1st Oregon volunteers set up camp near the present-day Camp Polk Bridge over Squaw Creek; in 1870, this site was homesteaded by Samuel Hindman. Shortly thereafter, he established the first store and post office in the area. In 1889, the Camp Polk post office was moved approximately 4 miles southwest to the village of Sisters.

Economic growth in the Sisters area began in the late 1800s, when several cattle and lumber companies were established. These businesses flourished until the turn of the century, when the cattle industry began to dwindle. Sisters is no longer a significant cattle-raising area, but the community has now become a major tourist attraction in the midst of a fast-growing recreational area (Reference 1).

Sisters has experienced little population growth since its incorporation in 1946. The population was 723 in 1950, decreased to 516 in 1970, and increased to 696 in 1980. The estimated population in 1982 was 730 (Reference 2). Growth in the outlying areas, however,

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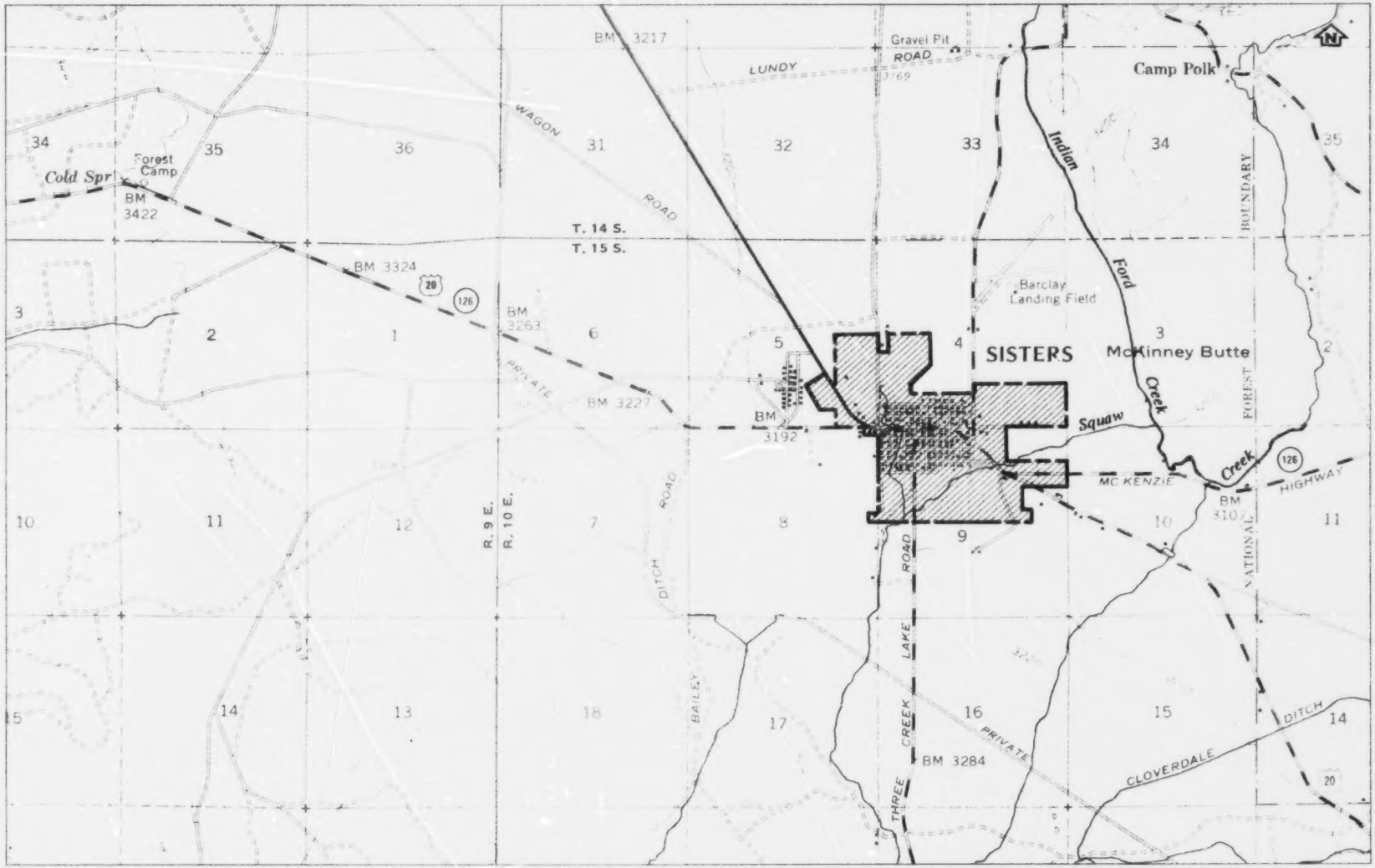

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF SISTERS, OR
(DESCHUTES CO.)

APPROXIMATE SCALE

1500 0 1500 3000 4500 FEET

VICINITY MAP

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has been rapid in recent years. According to the Deschutes County Building Department, approximately 1,200 people now permanently reside in the outlying areas surrounding Sisters (Reference 1).

From its headwaters on the north slope of Broken Top Mountain and the eastern slopes of the Three Sisters Mountains, to approximately 3 miles upstream of Sisters, Squaw Creek flows through deep canyons of volcanic origin. At this point, the constriction imposed by the canyon walls ceases, and Squaw Creek empties into a broad basin floor. The stream then meanders along this valley floor, through the City of Sisters, to the confluence with Indian Ford Creek, below which a second canyon section is encountered.

Squaw Creek has transported vast quantities of volcanic sediment from the canyons of its upper reaches to the valley floor near Sisters. The entire basin underlying Sisters and the nearby area is filled with the accumulated sediments of a series of overlapping alluvial fans. These sediments reflect their volcanic past and are composed of tuff, ash falls, and other debris of igneous origin. The vegetation cover of the flood plains through the study reach is primarily brush and small pine trees (Reference 1).

The transportation system serving Sisters includes U.S. Highway 20, State Highway 126, and several other State and county roads.

The climate of Sisters consists of warm, dry summers and cool, moist winters. Temperatures in the Sisters vicinity are usually mild. The average daily low and high for winter are 21°F and 44°F, respectively. Average daily low and high temperatures for the summer are 45°F and 85°F, respectively. The average annual precipitation in the study area is approximately 17 inches. However, portions of the upstream watershed of Squaw Creek have an average precipitation ranging from 80 inches near the Three Sisters Mountains to 100 inches near Mount Jefferson. Peak precipitation occurs during winter, with a second, lesser peak in May or June (Reference 1).

2.3 Principal Flood Problems

The annual flood season extends from November through April, with most of the larger floods occurring in November and December. Floods are a possibility whenever the rainfall is abnormally intense or prolonged, especially if the rain falls on an existing snowpack.

During floods, vegetation and other debris on the flood plain may be washed away and carried downstream to collect at bridges, diversion dams, and other obstructions to flow. When flooding occurs during a winter thaw, ice may also obstruct floodflows by lodging against bridges.

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In the valley area at and surrounding Sisters, the unconsolidated alluvial deposits that make up the streambed and its banks offer little resistance to erosion. During flooding, any large debris accumulation in the channel can divert flow sufficiently to erode one or both streambanks.

Of the two roads crossing Squaw Creek at Sisters, only Elm Street Bridge (Three Creek Lake Road) has experienced flood damage. No significant flooding of buildings should occur within the city during a 100-year flood as long as blockage of the stream channel due to deposition of debris does not occur.

Since April 1925, the USGS has maintained a stream gage on Squaw Creek, upstream of Sisters at River Mile (RM) 26.6. The four worst floods at this location occurred on December 25, 1980, on December 23, 1964, in November 1968, and on November 25, 1977. The discharge in cubic feet per second (cfs) and recurrence interval (years) for these events are 2,000 (83-year), 1,980 (80-year), 1,840 (65-year), and 1,330 (25-year), respectively (Reference 1).

The estimated 100-year discharge at the Squaw Creek gage location is 2,210. The heights that would be reached by the 100-year and 500-year floods at locations within the flood plain are shown in Figure 2.

2.4 Flood Protection Measures

There are no levees or other flood-control structures or projects, either existing or proposed, which would reduce flooding on Squaw Creek.

A series of irrigation diversion structures are located on Squaw Creek. The structures are used to divert some of the flow for irrigation purposes. Although the total flow is reduced, these structures are not considered to be flood control devices. High-velocity channel flow can deposit heavy accumulations of debris, gravel, and cobbles against these structures prior to a flood crest. This sudden partial blockage of the floodflow could result in increased water levels as much as 1,500 feet upstream of the structure (Reference 1).

Deschutes County has developed a flood plain ordinance that will make provisions for county-implemented flood plain regulatory measures that are based on the 1978 Squaw Creek Flood Plain Information Report and other pertinent reports. The City of Sisters recognizes these measures and is in compliance with the county ordinance by having a flood plain ordinance which precludes future development or redevelopment within the 100-year flood plain (Reference 3).

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Forecasting for Squaw Creek is the responsibility of the National Weather Service, Portland River Forecast Center. Since current reports of river observation are not presently available in the Squaw Creek Basin, forecast service is not provided for this area. However, flood warnings and stage forecasts which are provided for White River below Tigh Valley can be used as an index to the river conditions on Squaw Creek. These warnings and forecasts are disseminated through the Portland Weather Service Forecast Office.

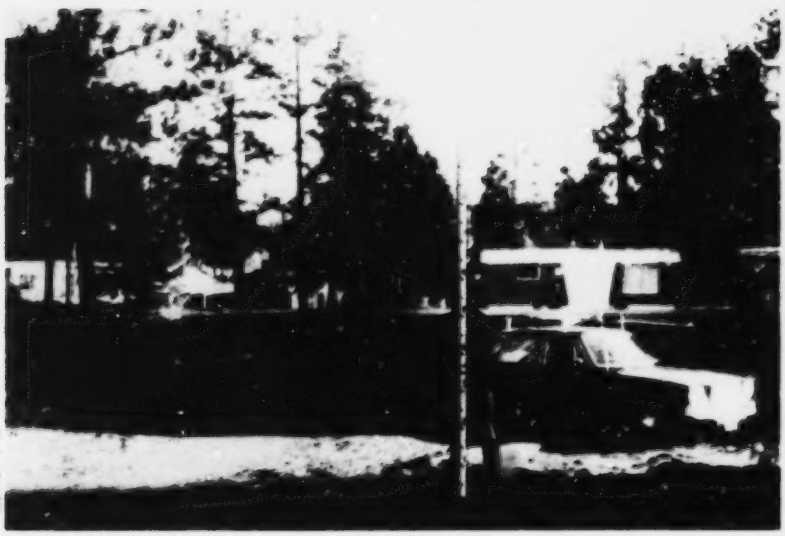

Figure 2. Possible Future Flood Heights Near Elm Street Bridge (Three Creek Lake Road)

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3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

This hydrologic analysis was carried out in December 1976 to establish peak discharge-frequency relationships for USGS gage No. 14075000 on Squaw Creek near Sisters, Oregon. The period of record from 1926 to 1975 (50 years) was used to establish these frequencies. U.S. Water Resources Council guidelines were used in the derivation of a Fall and Winter curve and a Spring and Summer curve (Reference 4). Data from 1906 to 1920 were available but not used because of uncertainty and discontinuity in the data.

Peak discharge-drainage area relationships for Squaw Creek are shown in Table 1.

Frequencies for these discharges were taken from the Fall and Winter discharge-frequency curve, because the largest floods occur during fall and winter.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

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Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Squaw Creek					
At USGS gage No. 14075000 (R.M. 26.6)	44	1,020	1,790	2,210	3,390
Upstream of Indian Ford Creek (R.M. 20.8)	51	1,140	2,000	2,480	3,800

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Water-surface elevations of floods of the selected recurrence intervals were computed using the COE HEC-2 step-backwater computer program (Reference 5). Cross sections for Squaw Creek were field surveyed and orthophoto maps developed from November 1976 aerial photography (Reference 6). Starting water-surface elevations were determined by the slope-area method at the Deschutes-Jefferson County line, approximately 12 miles downstream from Sisters. The model was calibrated using engineering judgment and information about past flooding events from residents along Squaw Creek. Bridges, dams, and culverts were field surveyed.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Boundary and Floodway Map (Exhibit 2).

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the stream and flood plain areas. Roughness values for the main channel of Squaw Creek ranged from 0.038 to 0.048, while the flood plain roughness values ranged from 0.065 to 0.110 for all floods.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps.

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study produces maps designed to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each

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cross section. Between cross sections, the boundaries were interpolated using topographic maps at a scale of 1:6,000, with a contour interval of 5 feet (Reference 6).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed on the basis of equal conveyance reduction from each side of the flood plain. The results of these computations are tabulated at selected cross sections for each stream segment for which a floodway is computed (Table 2).

As shown on the Flood Boundary and Floodway Map (Exhibit 2), the floodway boundaries were computed at cross sections. Between cross sections, the boundaries were interpolated. In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary has been shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Squaw Creek								
A	112,411	51	261	9.5	3171.9	3171.9	3171.9	0.0
B	112,834	45	288	8.6	3174.5	3174.5	3174.8	0.3
C	113,731	47	252	9.8	3180.5	3180.5	3181.0	0.5
D	114,734	107	279	8.9	3189.6	3189.6	3189.6	0.0
E	115,315	77	262	9.5	3197.5	3197.5	3197.5	0.0

[1]Feet Above Mouth

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF SISTERS, OR
(DESCHUTES CO.)

FLOODWAY DATA

SQUAW CREEK

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flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 3.

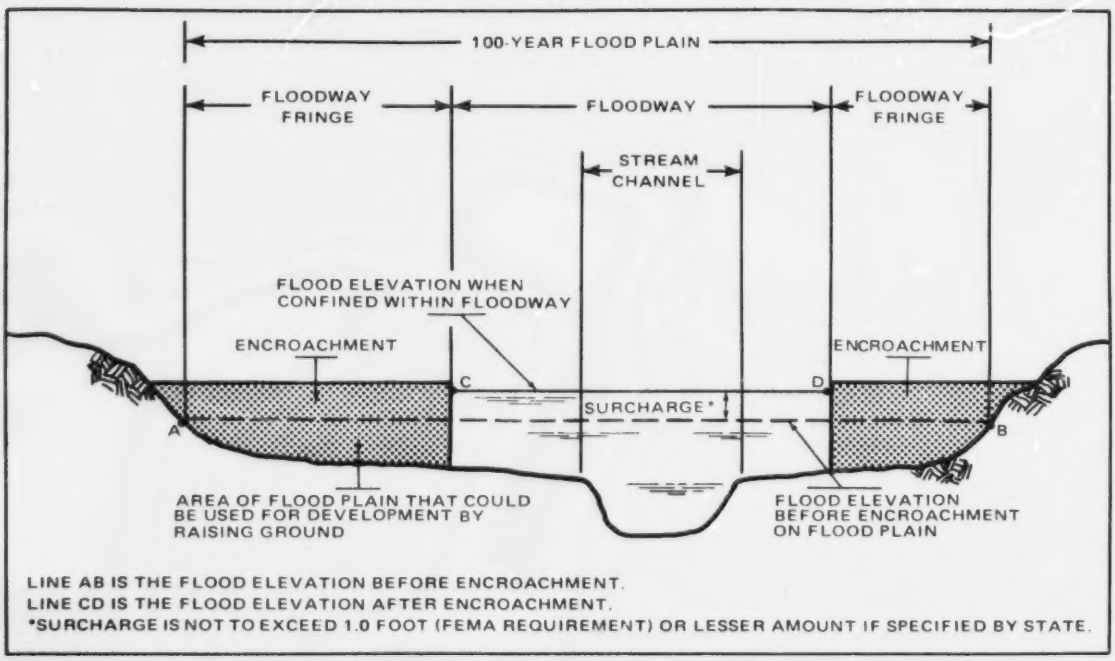
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

Figure 3. Floodway Schematic

5.0 INSURANCE APPLICATION

To establish actuarial insurance rates, data from the engineering study must be transformed into flood insurance criteria. This process includes the determination of reaches, Flood Hazard Factors, and flood insurance zone designations for each flooding source studied in detail affecting the City of Sisters.

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5.1 Reach Determinations

Reaches are defined as sections of flood plain that have relatively the same flood hazard, based on the average weighted difference in water-surface elevations between the 10- and 100-year floods. This difference may not have a variation greater than that indicated in the following table for more than 20 percent of the reach:

Average Difference Between 10- and 100-Year Floods	Variation
Less than 2 feet	0.5 foot
2 to 7 feet	1.0 foot
7.1 to 12 feet	2.0 feet
More than 12 feet	3.0 feet

The locations of the reaches determined for the flooding sources of Sisters are shown on the Flood Profiles (Exhibit 1) and summarized in Table 3.

5.2 Flood Hazard Factors

The Flood Hazard Factor (FHF) is used to establish relationships between depth and frequency of flooding in any reach. This relationship is then used with depth-damage relationships for various classes of structures to establish actuarial insurance rate tables.

The FHF for a reach is the average weighted difference between the 10- and 100-year flood water-surface elevations rounded to the nearest one-half foot, multiplied by 10, and shown as a three-digit code. For example, if the difference between water-surface elevations of the 10- and 100-year floods is 0.7 foot, the FHF is 005; if the difference is 1.4 feet, the FHF is 015; if the difference is 5.0 feet, the FHF is 050. When the difference between the 10- and 100-year flood water-surface elevations is greater than 10.0 feet, it is rounded to the nearest whole foot.

5.3 Flood Insurance Zones

Flood insurance zones and zone numbers are assigned based on the type of flood hazard and the FHF, respectively. A unique zone number is associated with each possible FHF, and varies from 1 for a FHF of 005 to a maximum of 30 for a FHF of 200 or greater.

Zone A3: Special Flood Hazard Areas inundated by the 100-year flood; with base flood elevations shown, and zones subdivided according to FHFs.

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Zone B:	Areas between the Special Flood Hazard Areas and the limits of the 500-year flood; areas that are protected from the 100- or 500-year floods by dike, levee, or other local water-control structure; areas subject to certain types of 100-year shallow flooding where depths are less than 1.0 foot; and areas subject to 100-year flooding from sources with drainage areas less than 1 square mile. Zone B is not subdivided.
Zone C:	Areas of minimal flood hazard; not subdivided.

The flood elevation differences, FDFs, flood insurance zones, and base flood elevations for each flooding source studied in detail in the community are summarized in Table 3.

5.4 Flood Insurance Rate Map Description

The Flood Insurance Rate Map for the City of Sisters is, for insurance purposes, the principal product of the Flood Insurance Study. This map contains the official delineation of flood insurance zones and base flood elevations. Base flood elevation lines show the locations of the expected whole-foot water-surface elevation of the base (100-year) flood. The base flood elevations and zone numbers are used by insurance agents, in conjunction with structure elevations and characteristics, to assign actuarial insurance rates to structures and contents insured under the NFIP.

6.0 OTHER STUDIES

Flood Hazard Boundary Maps were prepared for the City of Sisters (Reference 7), and for Deschutes County (Reference 8). However, this study represents a more detailed analysis and therefore supersedes these Flood Hazard Boundary Maps.

The results of a COE 1978 Flood Plain Information report for Squaw Creek were used in this Flood Insurance Study, including water-surface profiles and flood plain areas (Reference 1). The reaches of Squaw Creek, covered in that report were also shown on the COE orthophoto topographic (Reference 6).

7.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological

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FLOODING SOURCE	PANEL[1]	ELEVATION DIFFERENCE[2] BETWEEN 1% (100-YEAR) FLOOD AND			FLOOD HAZARD FACTOR	ZONE	BASE FLOOD ELEVATION (FEET NGVD)[3]
		10% (10-YEAR)	2% (50-YEAR)	0.2% (500-YEAR)			
Squaw Creek	0001	-1.72	-0.5	1.1	015	A3	Varies - See Map

[1]Flood Insurance Rate Map Panel [2]Weighted Average [3]Rounded to Nearest Foot

TABLE 3

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF SISTERS, OR
(DESCHUTES CO.)

FLOOD INSURANCE ZONE DATA

SQUAW CREEK

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Hazards Division, FEMA, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98011.

8.0 BIBLIOGRAPHY AND REFERENCES

1. U.S. Department of the Army, Corps of Engineers, Portland District, Flood Plain Information Report, Squaw Creek, Sisters, Oregon, August 1978

2. Secretary of State, Oregon Blue Book, 1983-1984, Norma Paulus, February 1983

3. City of Sisters, City of Sisters Comprehensive Plan, adopted September 20, 1979, approved September 28, 1979, by Deschutes County

4. U.S. Water Resources Council, "Guidelines for Determining Flood Flow Frequency," Bulletin 17, March 1976

5. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water Surface Profiles, Generalized Computer Program, Davis, California, November 1976, updated May 1982

6. U.S. Department of the Army, Corps of Engineers, Portland District, Orthophoto Topographic Map, scale 1:6,000, Contour Interval 5 feet, Squaw Creek, vicinity of Sisters, Oregon, August 1978

7. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, City of Sisters, Oregon, Scale 1:8,400, Revised April 23, 1976

8. U.S. Department of Housing and Urban Development, Federal Insurance Administration, Flood Hazard Boundary Map, Deschutes County, Oregon, Scale 1:24,000, Revised September 6, 1977

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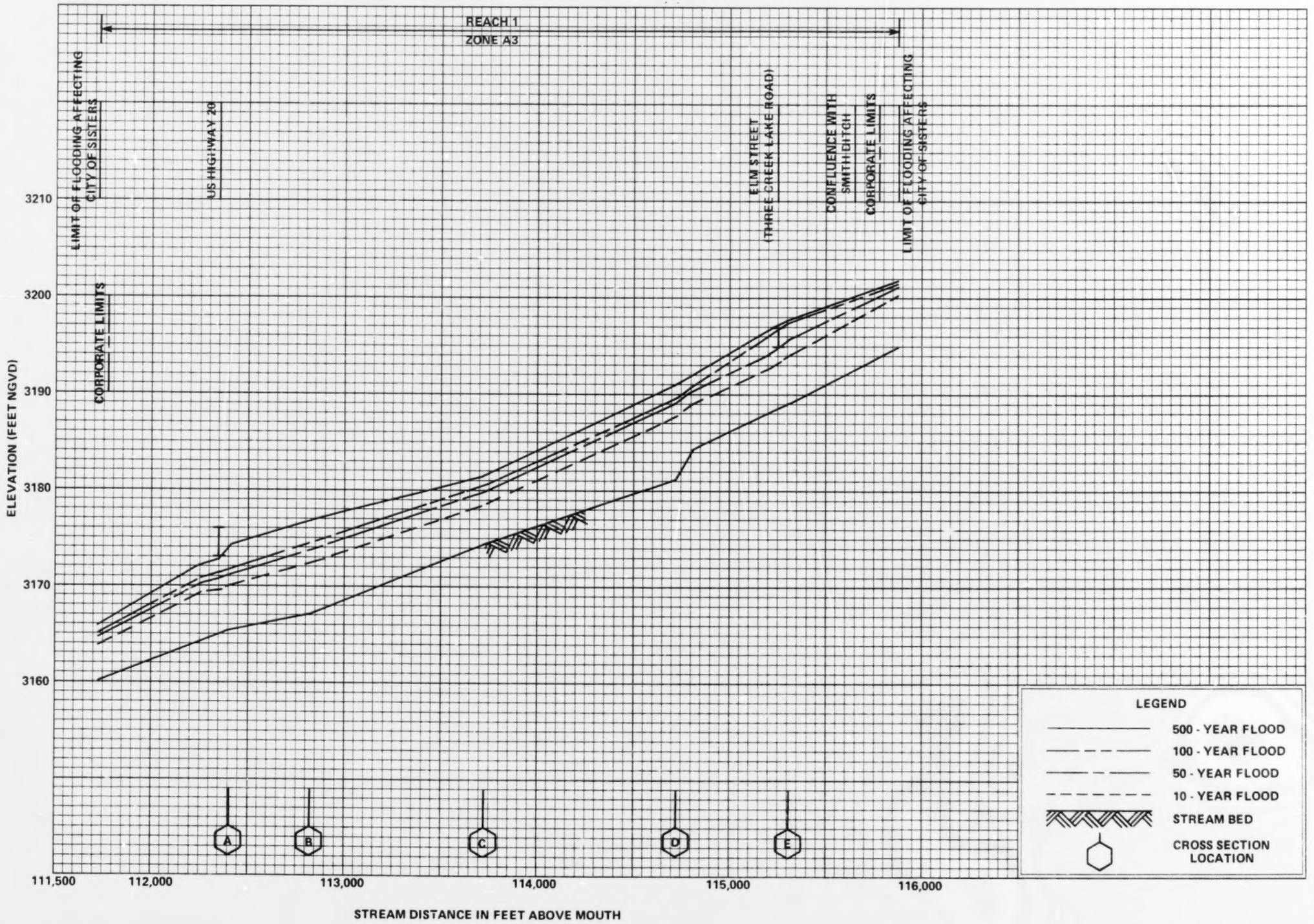

FLOOD PROFILES

SQUAW CREEK

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF SISTERS, OR
(DESCHUTES CO.)

01P

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